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Geologic Section of the Chillicothe Test-Core

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GEOLOGIC SECTION OF THE CHILLICOTHE TEST-CORE

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In the autumn of 1944 the Engineering Experiment Station of The Ohio State University put down a test boring southwest of Chillicothe, Ohio, for the purpose of obtaining a drill core for the determination of the petroleum content of the Ohio shale, foot by foot. Mr. L. C. Karrick, formerly of the U. S. Bureau of Mines, where he had had much experience in analyzing oil shale and coal, supervised the taking of the core and made the analyses for petroleum. A report on this study will be published by the Engineering Experiment Station at an early date.

The Experiment Station officials[1] allowed the writer to study the core and after the analyses were made, the unused parts were turned over to the Department of Geology. These include alternate ½-inch sections of the core through the Ohio shale and the complete core through the other formations.

The location of the test well is about three miles southwest of Chillicothe, on the south slope of Paint Creek Valley on the Hirsh Orchard Farm.[2] This is in the edge of the Appalachian Plateau where the surface is rugged and the local relief is 400 to 600 feet. A north-south cross section sketch of Paint Creek Valley is shown in Figure 1. The elevation of Paint Creek is here about 610 feet. The valley is broad with steep slopes which rise to a bench at 880 to 900 feet. Just below the edge of the bench the Berea sandstone commonly crops out in a cliff at the top of the steep valley side where it is undermined by the more rapid weathering and slumping away of the softer Bedford shale below. The lower slopes are at the level of the Ohio shale which is rarely exposed. The bench is at the horizon of the Sunbury shale and the overlying Cuyahoga shale which have been worn away more rapidly than the more resistant Berea sandstone below. The bench on the south is about one-fourth of a mile wide and beyond this the surface rises to a hill capped with a sandstone unit of the Logan formation at an elevation of 1260 feet.

The test boring is located near the edge of the bench at an elevation of about 880 feet. The total depth is 577 feet and the bottom of the well should have an

[1]C. E. MacQuigg, Director; J. R. Shank, Assistant Director; T. H. Kerr, Supervisor of Fuels Research.

[2]From the Hirsch farm house on the south side of Paint Creek Road, a private farm road extends southwest for about one-fourth of a mile, up the slope along the course of a small run to the orchard located on a bench. The test boring is located about 50 yards northeast of where the farm road comes out of the head of the ravine onto the bench. The location of the test boring is in the southeast part of the Roxabell quadrangle, approximately 3300 feet S. 78° W. from the road fork which is just south of Paint Creek and one-eighth of a mile west of the east line of Huntington Township.

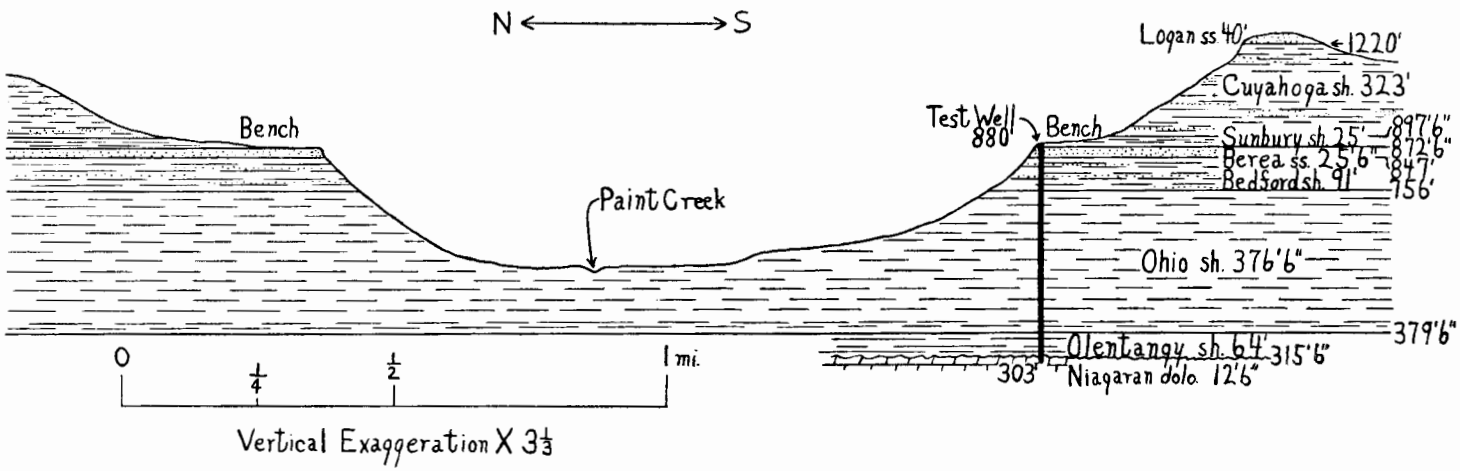

FIG. 1. North-south cross section of Paint Creek Valley about 3 miles southwest of Chillicothe, passing through the Chillicothe test well.

elevation of about 303 feet, at about 300 feet below the level of Paint Creek. The section of rock units penetrated is as follows:

Rock Unit	*Thickness* Ft.	In.	*Depth to Base* Ft.	In.
Mantle rock	6	6	6	6
Sunbury shale	1	0	7	6
Berea sandstone	25	6	33	0
Bedford shale	91	0	124	0
Ohio shale	376	6	500	6
Olentangy shale	64	0	564	6
Niagaran dolomite	12	6	577	0

The first study of the core was very detailed in an attempt to separate every recognizable zone or unit. In this study 114 zones were separated and described. In a later study this was reduced to 35 zones and again to a general section of 16 zones which is given below.

GEOLOGIC SECTION OF THE CHILLICOTHE TEST CORE

	Ft.	*In.*
Mantle rock. 6 feet, 6 inches.		
1. Clay and fragments of yellow sandstone	6	6
Sunbury shale. 1 foot.		
2. Black, fissile shale with *Lingula melia* and *Orbiculoidea herzeri*	1	0
Berea sandstone. 25 feet, 6 inches.		
3. Medium-grained, blue-gray sandstone with thin shaly partings	25	6
Bedford shale. 91 feet.		
4. Interbedded thin laminae and lenses of blue-gray sandstone and shale, with a few layers of sandstone 2 to 12 inches thick in the upper half and a 3-inch layer of sandstone at the base	22	6
5. Interbedded thin laminae and lenses of blue-gray sandstone and dark-blue shale in about equal amounts	20	0
6. Interbedded thin laminae and lenses of dark-blue shale and blue-gray sandstone with a few layers of sandstone 1 to 4 inches thick	26	6
7. Interbedded dark-blue and blue-gray shale with a few laminae and thin layers of sandstone in the upper half	22	0
Ohio shale. 376 feet, 6 inches.		
8. Black shale with *Lingula*, fishplates, conodonts and macrospores	25	6
9. Black to brownish-black shale with *Lingula*, fishplates and macrospores	44	0
10. Black shale with a few layers of blue shale 2 to 6 inches thick	5	6
11. Brownish-black and blue-gray shale in interbedded thin layers and laminae	21	0
12. Brownish-black shale with a few layers of blue-black and blue-gray shale and with a few gray, calcareous partings in the lower half	48	9
13. Brownish-black shale with thin layers and lenses of blue-black shale	168	6
14. Brownish-black shale with a few 2- to 6-inch layers of blue-gray shale	63	3
Olentangy shale. 64 feet.		
15. Blue-gray shale with layers of brownish-black, especially in basal 5 feet. *Lingula*, conodonts and macrospores in basal 2 feet	64	0
Niagaran dolomite. 12 feet, 6 inches.		
16. Bluish-gray to brownish-gray dolomite with quite variable texture	12	6

The highest bedrock present at the site of the test boring is the basal one foot of the Sunbury shale. Lying just below the mantle rock, this shale was greatly weathered and was not saved in the drill core. It was penetrated also in an excavation for a water-basin just beside the test boring and small fragments from this excavation showed the typical, black, fissile Sunbury shale, as well as the two characteristic fossils *Lingula melia* and *Orbiculoidea herzeri* which are so persistently present in central Ohio in the basal six inches of the Sunbury shale.

The upper five feet of the Berea sandstone of this core is much broken by weathering, yellow to buff in color, and contains thin partings and veins of ferruginous material. The lower half is argillaceous to shaly sandstone with an increasing number of partings and thin layers of shale downward. In fact the contact between the Berea and the Bedford must be somewhat arbitrarily chosen. There is no suggestion of a break between them.

The distinctive feature of the Bedford is the prominent and persistent alternation of thin layers and lenses of sandstone and shale within which are also a few definite layers of sandstone, increasing in thickness and number upward through the formation. In Franklin and Delaware counties most of the Bedford is soft clay shale with sandy laminae and thin layers in the upper 20 to 30 feet in some exposures. In the test-core section only the basal 10 to 15 feet is clay shale and all the rest contains abundant lenses and thin layers of sandstone The first appearance of arenaceous sediments came earlier in Ross County than in Franklin County. Further, the soft chocolate-brown clay shale that forms the middle part of the Bedford in Franklin and Delaware counties is not present in the test-core section. In the basal few feet of the Bedford of the test-core the fossils *Lingula* and *Orbiculoidea* were seen. They were very poorly preserved impressions, unidentifiable as to species. They were probably *Lingula meeki* and *Orbiculoidea newberryi* which are part of the larger fauna found in the basal two feet of the Bedford shale in Franklin County.[3] The contact of the Bedford with the Ohio shale below is definitely conformable.

The Ohio shale is black to brownish black with thin layers of blue-black to blue-gray shale. It is very uniform in color and texture and the slight differences upon which zones may be based in this test-core section could not be expected to hold laterally over large areas. In general the highest 75 feet is the blackest part and has the fewest bluish layers while the lowest 75 feet has the most bluish shale. That part between 75 and 150 feet below the top of the Ohio shale has a few thin, gray, calcareous partings.

Fossils found in the Ohio shale of this core include conodonts, minute fishplates, macrospores, and the brachiopod, *Lingula*. These fossils have not yet received the detailed microscopic study which most of this material requires and only general statements will be made concerning them.

The only invertebrate found is the brachiopod *Lingula*, of which there are two species: a smaller, elongate, subrectangular form about one-fourth of an inch long, apparently *Lingula spatulata*, and a larger, broader, more oval form about half an inch long. The smaller form was seen in the black shale at a number of levels in the upper 70 feet of the Ohio, at 91 feet below the top in blue shale, and at several levels at 4 to 12 feet above the base in mixed black and blue shale. The larger form was found at 83 and 91 feet below the top and at 18 feet above the base, all in blue-gray shale.

A number of conodonts were found in the upper 12 feet of the Ohio shale where the study was made with the binocular microscope. Below this level the microscope was not used and only a few conodonts were seen but it is probable that an examination with the microscope would reveal them throughout most of the formation. Several types of conodonts were recognized.

Small, black, glossy plates about one-eighth of an inch across, of several shapes and markings, were found at various levels in the Ohio shale. They resemble ganoid fish scales and apparently belong to the Rhadnichthids as figured by Branson from the Ohio shale of northern Ohio.[4]

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[3]Stauffer, C. R., Columbus Folio: U. S. Geol. Survey Folio 197, 1915, p. 7.

[4]Branson, E. B., Notes on the Ohio Shales and their Faunas: The University of Missouri Bulletin, Science Series, Vol. 2, No. 2, 1911, pp. 23-32.

The most abundant fossil of the Ohio shale is the minute, round, amber-colored macrospore, .25 to .5 millimeter in diameter known as *Protosalvinia huronensis*. They are common in the upper 25 feet of the formation and below this to about 200 feet they are present but uncommon. From 200 feet to the base at 376½ feet they are common and at some partings so abundant as to almost cover a bedding surface and give to it a brown color.

A very definite contact can be drawn between the Ohio and the Olentangy shales, but also it is a very definitely conformable contact. The lithologic difference between the two formations is only a matter of percentage of the kind of material making up both formations. The Ohio is dominantly black or brownish-black shale with layers of blue-black or blue-gray shale while the Olentangy is dominantly blue-gray shale with layers of brownish-black shale, which in this test-core section continue to the base of the Olentangy, for here the basal 3 feet is the blackest part of the formation. This section shows a close relation for the two formations, which should mean a close age relation. It supports the conclusions of Lamborn that the Olentangy shale of southern Ohio "is a basal phase of the Ohio shale and therefore Upper Devonian in age."[5]

Parts of the blue shale of the lower two-thirds of the Olentangy are slightly calcareous and the lower one-third contains small nodules or thin layers of calcareous material. Pyrite nodules were found at several horizons and also lenses and layers with much disseminated pyrite. Plant impressions or carbon films were seen at three horizons and a thin layer of grainy, fragmental material at two feet about the base yielded several types of conodonts, macrospores, and a few distorted specimens of a small Lingula.

The base of the Olentangy is firmly joined through a ½-inch, transition unit of grainy or fragmental material, to a crystalline dolomite below. The contact is uneven and it is definitely a disconformable contact. This dolomite was penetrated to a depth of 12 feet 6 inches, the bottom of the test boring. The dolomite is bluish-gray to brownish-gray and quite variable in texture. In part it is firmly crystalline and compact; in part of very rough texture with open spaces containing petroliferous staining; at places apparently brecciated as if crushed reef-material; the basal 4 feet is largely oolitic dolomite. No identifiable fossils were found in the dolomite but in the porous, crushed reef-rock material there are structures that suggest the compound coral *Favosites* and concentrically laminated masses suggesting stromatoporoids, all greatly altered. Although not absolutely conclusive, the evidence indicates that this dolomite is upper Niagaran, probably about the equivalent of the Peebles dolomite of Highland and Adams counties. That is, the Upper Devonian shale rests disconformably on Middle Silurian dolomite.

Passing southward from central Ohio the Olentangy-Ohio unit overlaps the outcrops of the Delaware and Columbus limestones in Pickaway County and thence southward to the Ohio River rests upon either the Greenfield or Niagaran dolomites. Further, in many of the sections of eastern Highland and Adams counties the Olentangy blue shale unit is missing and the Ohio black shale rests upon the Greenfield or Niagaran. This is readily explained by the interpretation that the Olentangy is merely a non-carbonaceous phase of the greater Ohio shale, a phase which was formed generally, but not everywhere, during the early part of the Ohio shale stage, being contemporaneous with black shale which was forming elsewhere.

The test-core section shows 64 feet of Olentangy shale between the Ohio shale and the dolomite. However, on the outcrop, 20 miles to the west near Greenfield, or 16 miles to the west-southwest near Bainbridge, the Ohio shale rests directly on the dolomites. This may mean that the deposition of the black sediments

[5]Lamborn, Raymond E., The Olentangy Shale in Southern Ohio: Jour. Geol., Vol. 35, 1937, p. 722.

was at a later time and extended farther westward on the old erosion surface than did the blue sediments, or more probably it means that the sediments laid down farther west at Greenfield and Bainbridge contained enough carbonaceous material to make black shale while farther east at the test-core site, contemporaneous deposits without carbonaceous material resulted in blue shale. This accords with the usual interpretation of an eastward source for the Upper Devonian sediments, which were carried westward into a shallow, possibly stagnant, sea area where plant growth furnished the carbonaceous material for making black shale.

The test-core section shows that the west edge of the Columbus-Delaware limestone unit which is overlapped in west central Pickaway County, must run southeast or southeast-by-east in order to pass east of the test-core site which is 16 miles east and about 20 miles south of where the limestones are overlapped. It also shows that the Silurian-Devonian disconformity, which along the outcrop in eastern Highland County is at approximately the contact of the Greenfield dolomite on the Niagaran dolomite does not rise eastward across the dip of the strata, but descends eastward with a somewhat greater dip than the strata in order that the Devonian shales rest on the Niagaran at the test-core site. The base of the Devonian shales, which on the outcrop south of Greenfield has an elevation of about 970 feet, drops to about 315 feet at the test-core site; a drop of about 655 feet in 20 miles to the east, or about 33 feet per mile, which is approximately the regional dip of this part of the state. Assuming that the old erosion surface which truncates the Silurian dolomites was approximately horizontal and that the Upper Devonian shales were laid essentially horizontal, it appears that all the regional dip was produced in post Devonian time.